

AD-A277 521



MENTATION PAGE

Form Approved
OMB No. 0704-0188

(2)

is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering the data, reviewing the collection of information, Send comments regarding this burden estimate or any other aspect of this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson I to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

REPORT DATE

March 94

3. REPORT TYPE AND DATES COVERED

Scientific Paper

4. TITLE AND SUBTITLE

A Foundation for Fusion

5. FUNDING NUMBERS

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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Alexandria, VA 22310-3864

8. PERFORMING ORGANIZATION
REPORT NUMBER

R-212

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING
AGENCY REPORT NUMBER

94-09619



11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release;
distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The U.S. Army Topographic Engineering Center (TEC) is a Corps of Engineer laboratory located at Ft. Belvoir, Virginia. Its mission is to perform research and development in the topographic sciences, whatever they may be. Actually, while you can't take a course of study in the topographic sciences, they represent a select grouping of technologies which form a foundation for data fusion on the battlefield.

DTIC QUALITY INSPECTED 8

Dist

Special

A-1

14. SUBJECT TERMS

hyperspectral, data fusion, imagery, radars

15. NUMBER OF PAGES

7

16. PRICE CODE

17. SECURITY CLASSIFICATION
OF REPORT

unclassified

18. SECURITY CLASSIFICATION
OF THIS PAGE

unclassified

19. SECURITY CLASSIFICATION
OF ABSTRACT

unclassified

20. LIMITATION OF ABSTRACT

A FOUNDATION FOR FUSION The Program at the Topographic Engineering Center

**by George N. Simcox
Advanced Systems Concept Officer**

The U.S. Army Topographic Engineering Center (TEC) is a Corps of Engineer laboratory located at Ft. Belvoir, Virginia. Its mission is to perform research and development in the topographic sciences, whatever they may be. Actually, while you can't take a course of study in the topographic sciences, they represent a select grouping of technologies which form a foundation for data fusion on the battlefield.

For centuries armies have used maps and charts to record the terrain over which they were to conduct operations and record new information. The first case of multiple sensor fusion was probably two spies pointing out enemy dispositions to their commander via a drawing on the ground. As technology progressed the drawings in the sand gave way to portable representations much like the maps we use today. Data gathering improved with the advent of balloons, then aircraft and now satellites. Somewhere along the way someone got the idea of putting the map in a computer and on an electronic display. There is now a major program underway in the Defense Mapping Agency (DMA) and the Army to make this a practical reality. Programs have been completed which put a map into a data base which could guide weapon systems, such as the highly successful Cruise Missile and the Pershing II, the former using elevation matrix matching for in-flight guidance and the latter, image matching for terminal guidance. We had machine readable maps - a new era in weaponry. Topographic R&D was a major contributor to these advances.

TEC is now developing the technologies which will provide similar advances in the future. TEC intends to meet the need expressed by Vice Admiral Macke for "a fused, real-time, true representation of the Warrior's battlespace." I would like to bring a few of these activities to your attention and provide a view of topography in the year 2000.

TEC has had a continuing interest in getting the best sensor mix available to gather data for its portrayal of the world. In addition to a very active program to investigate the use of radar interferometry to provide better elevation data for the battle command staff, TEC is also developing the basis for the Army's use of an emerging family of hyperspectral data acquisition platforms. This work involves gathering data on spectral signatures for natural and man-made features and then developing a practical way to quickly read the data or imagery provided to produce militarily relevant information.

Data Acquisition leads us to the first step in the Topographic Model:

DATA GENERATION-ANALYSIS-DISPLAY and REPRODUCTION. I would like to use this model as a framework for the remainder of the presentation. Keep in mind that this work is being performed primarily to support the soldier in the field and, as such, supports the DoD initiative, C4I for the Warrior.

DATA GENERATION can take many forms. In the TEC world we are talking about using multisensor images to derive data which can be processed to the next level, analysis. Currently we have, under development, a stereo data viewing and manipulation work station which allows direct measurements on stereo imagery and viewing an image from various perspectives based on those measurements. It also permits the generation of coded terrain information for placement in a geographic information system. Automated elevation determination software permits the rapid extraction of digital terrain matrices which can be used to provide realistic image "fly-through," and support to weapon systems which use digital elevation information for target location and guidance. This technology is an essential element for fusing information against a common reference. Initiatives are underway to develop capabilities for rapid data generation from an emerging family of hyperspectral sensors.

DATA ANALYSIS takes the generated information and places it in an operational context. Software for tactical computers will allow the commander to pose questions to the terrain data base: Considering my equipment mix, what are my best avenues of advance? Where is the greatest potential for ambush? Where will my opponent likely place his mines and barriers? Where can I best direct my fires to guard my flank during the assault phase of my operation? What is my opponents likely use of terrain to attack me? The questions are endless - the software to provide answers is not, but we are working on it. While data generation focuses on terrain, analysis requires the fusion of information about the terrain, weather, systems performance, friendly and enemy doctrine and yes, even the propensity of a particular opponent to select a course of action. Initially the TEC program focused on automating the manual process to produce hard copy products. We then initiated the use of artificial intelligence approaches to produce expert systems to assist with the analysis. These approaches are beginning to bear fruit. We are now pursuing approaches for ARPA (Advanced Research Projects Agency) which employ image understanding technologies to speed the information analysis and fusion. Our first success has been in the area of radar analysis through the Image Exploitation System/Balanced Technology Initiative. Using radar images, enemy doctrine and terrain information, the system has successfully identified troop units and their disposition. This program continues, seeking to integrate other sensors to make it a truly multisensor system. This work has resulted in ARPA looking to TEC to develop its Intelligence and Planning component of **WARBREAKER**, a program focused on the joint staff planning function in bringing fires on target in minutes rather than the hours and days it took during Desert Shield/Storm.

DISPLAY AND REPRODUCTION considers how the information

derived can be presented to the user so that it is rapidly assimilated and easily understood. For years we concentrated on speeding the map-making process, with some success, to be sure, only to find that, "surprise - surprise" troops were having difficulty reading and understanding our product. Besides, they were bulky to carry around and it seemed that major battles were always being fought at the juncture of map sheets so that a lot of time was spent cutting and pasting the product we mappers produced to make a useful product for the commander. Advances in computer technology, hardware and software, are permitting a change to our approach. Maps can be digitized and placed into the computer for on-screen viewing making the seams invisible to the viewer. Yet, two major problems remained, the map solution did not provide any detailed terrain information which could be manipulated to answer a commander's questions, nor did it assist in understanding the information presented by the map.

To standardize digital terrain data so that it could be provided and manipulated, TEC developed and proposed a specification for Tactical Terrain Data (TTD) to be used as the standard for presenting terrain data to combat systems. This standard, following some modification by DMA, will be produced starting in 1996. To cover the need for data during the intervening period, Interim Terrain Data is being produced for high priority areas of Army interest.

Making use of advances in computer generated images, TEC initiated programs to provide software which would read digital data and convert the information into images which would present the data in perspective, appearing as though it were a painted picture. Using the underlying data base, questions regarding line-of-sight and mobility could be answered with a degree of certitude. When aerial or space photographs are used as tiles for the displays, they take on a degree of realism which can be astonishing, aiding in understanding the information but sometimes it is too information rich to be easily comprehended, hence both computer generated images and overhead images are used, depending on the need of the commander. Computer generated terrain walks will be possible for battle planning, rehearsal and training. This will require the fusing of information about forces, their location and disposition and routes of advance, suitable challenges for those of you attending this conference.

Developments in this technology have led to simulation schemes such as the Joint Precision Strike Demonstration Program which will provide the framework for evaluating proposed changes in doctrine, systems and tactics and the identification of simulated environments as a major DoD interest. TEC is also working on programs to portray environmental effects such as smoke and fog in the simulation environment. A commander can enter the current weather forecast into his system and view the probable effect of the use of obscurants by himself and the enemy as well.

Where do we go from here? Onward and upward, of course. Would I bring you a dying program? The force in the year 2000 will be "topo rich."

Working with other government laboratories, TEC will produce systems that put terrain in the hands of the soldier and his squad leader. These systems will answer such questions as: Where am I? Where am I trying to go? What is the best route to take to get there? Systems we are delivering to the field today such as the Digital Topographic Support System are the first step in an evolutionary development and fielding strategy relying on technology upgrades to meet the challenges of the future which are posed by the rapid pace of technology development. We will support you in your efforts to fuse information on the battlefield by providing the underlying geospatial data in the form you need and the visualization techniques to understand the effects of the environment on your system. Working together, we can forge a partnership in development which will make the future commander the envy of his opponent. Help us to TAKE THE CONFUSION FROM FUSION.

THE WARRIOR NEEDS:

**"A FUSED, REALTIME, TRUE REPRESENTATION OF
THE WARRIOR'S BATTLE SPACE - AN ABILITY TO ORDER,
RESPOND AND COORDINATE HORIZONTALLY AND
VERTICALLY TO THE DEGREE NECESSARY TO PROSECUTE
HIS MISSION IN THAT BATTLESPACE"**

11

**VADM Richard C. Macke, USN
Director of Command, Control,
Communications and Computer Systems (J6)
The Joint Staff**

TAKE THE CONFUSION FROM FUSION

GEOSPATIAL DATA TO THE RESCUE

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